Atherinosoma wallacei, a new species of estuarine and inland water silverside (Teleostei: Atherinidae) from the Swan-Avon and Murray Rivers, Western Australia

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ABSTRACT

Atherinosoma wallacei n.sp., is a common estuarine and inland water silverside or hardyhead having close affinities with the marine *Atherinosoma presbyteroides*. It is placed in *Atherinosoma* after examination of all the 18 existing type specimens representing the species found in this genus in Western Australia. Priority of *Atherinosoma* is confirmed.

INTRODUCTION

An annotated checklist of the fish fauna of the Swan-Avon River system in south-western Australia was compiled by Chubb *et al.* (1979) based on the records of the Western Australian Museum and a bi-weekly sampling programme at various sites within the estuary between February 1977 and March 1978. Identification of most teleosts posed few problems except for those of the Atherinidae. Although Chubb *et al.* tentatively listed two species for the genus *Atherinosoma,* namely *A. presbyteroides* (Richardson, 1843) and *A. elongata* (Klunzinger, 1879), subsequent work indicated that these designations were incorrect. A detailed study of the distribution, abundance and species composition of *Atherinosoma* within the Swan-Avon estuary was therefore initiated. It soon became evident that the problems posed in compiling the Swan-Avon checklist were due to the presence of an undescribed species which was closely related to the marine species *Atherinosoma presbyteroides.* This species is named *Atherinosoma wallacei* sp. nov. The taxonomic characters of this species and those of the other two species of *Atherinosoma* found in south-western Australia, namely *A. presbyteroides* and *A. elongata,* are compared.

TAXONOMIC BACKGROUND

Considerable confusion has existed over the generic status of several species of hardyheads or silversides in southern waters of Australia. As the work of

Ivantsoff (1978) has shown, this applies particularly to *Atherinosoma,* which is the predominant atherinid genus in this region. To understand the basis for placing the new species described in this paper in *Atherinosoma,* it is necessary to outline the problems surrounding the nomenclature of this genus and its species. A more detailed account of all the species in this genus is currently being prepared by one of us (W.I.).

Atherinosoma was erected as a monotypic genus by Castelnau (1872) to recognise the difference between his new species *Atherinosoma vorax* (of which no type specimens have survived) and species belonging to Northern Hemisphere atherinid genera. In 1895, Ogilby published a new name *Taeniomembras,* based on *Atherina microstoma* Günther, 1861. Ogilby's genus was accepted by subsequent workers such as McCulloch (1911) and Schultz (1948). Munro (1958), in his account of Australian atherinids, listed eight species in *Taeniomembras.* Without explanation, Whitley (1943) resurrected *Atherinosoma* Castelnau, 1872, to incorporate a number of species already placed in the genus *Taeniomembras* by Munro and other workers, including *Atherina microstoma.* A newly described species *Atherinosoma rockinghamensis* Whitley, 1943, and *Atherina elongata* Klunzinger, 1879, were also placed by Whitley (1943) in *Atherinosoma.* It appears that Whitley believed that *Atherinosoma vorax,* the type species of Castelnau's genus, was related to *Atherina microstoma* of Günther. Castelnau's (1872) clear account of *A. vorax,* especially the description of hooked teeth in jaws and the presence of teeth on the palatines and tongue, as well as a count of 36 scales along the mid-lateral line, leaves little doubt that *A. vorax* is the same as *Atherina microstoma.* This conclusion is supported by the fact that no other silverside species from Victoria and Tasmania, which are the type localities for the above mentioned nominal species, has fewer than 40 mid-lateral scales. The hooklike teeth in jaws, and teeth on the tongue and palatines, are typical of *A. microstoma.*

Atherina, an exclusively Northern Hemisphere genus, has been frequently used as a "catch-all" genus for the Australian species of silversides, especially those which are now included in *Atherinosoma. Atherina* differs from *Atherinosoma* in the skull roof morphology, in the shape of maxilla and by the presence of enlarged haemal arches. The two are therefore regarded as distinct. An investigation of Australian atherinids by Ivantsoff (1978) identified only three species that should be placed in the genus *Atherinosoma,* namely *A. microstoma, A. elongata* and *A. presbyteroides.*

The validity of the names *A. elongata* and *A. presbyteroides* requires some explanation. Examination of these types (Stuttgart Museum, S93, 2574C) demonstrated that *Atherina elongata* Klunzinger, 1879, is the senior synonym of *Atherinosoma edelensis* (*sensu* Whitley, 1955, 1958) and *A. rockinghamensis* (see Ivantsoff, 1978). However, the name *Atherinosoma elongata* (or *Taeniomembras elongatus*) has been used by some workers to describe an elongate hardyhead possessing greater than 15 gill rakers in the first lower gill arch, having a mid-lateral scale count of 40-44 (Whitley, 1955, 1958; Munro, 1958) and having a long median premaxillary process. Since the osteological characters of *Atherinosoma elongata* used by Whitley and Munro do not agree with the type specimens of *Atherina elongata* (the types are in extremely bad condition), it is evident that the species described by them was an entirely different hardyhead.

The status of *Atherina presbyteroides* has been enigmatic since its description by Richardson in 1843. Although the types are lost, the description of this Tasmanian species specifies the premaxilla as not protractile and that there are 46 vertebrae and two rows of scales above the mid-lateral band. These characters make *A. presbyteroides* indistinguishable from *Atherina tamarensis* Johnston, 1883, *Atherinichthys edelensis* Castelnau, 1876, and *Taeniomembras elongata* (*sensu* Whitley, 1943).

MATERIALS AND METHODS

Source of material

The specimens used in the description of *A. wallacei* came primarily from the Swan-Avon River system (Lat. 32°04′, Long. 115°44′) and to a lesser extent from the Murray River which flows into the Peel-Harvey estuarine system (Lat. 32°35′, Long. 115°45′). The Swan-Avon River system has been defined by Jutson (1934) as comprising three rivers and their tributaries, namely the Swan-Avon, Helena and Canning. Sampling was carried out with beach seines in 1978, 1979 and 1980 (generally at least once monthly) at a number of sites in the lower, middle and upper estuary of the Swan-Avon complex (Chalmer, Hodgkin and Kendrick, 1976).

For a full description of the precise sampling method and the location of the sites see Chubb *et al.* (1981). Samples were also examined from Walyunga and Northam in the Swan-Avon located approximately 45 and 95 km respectively upstream from the mouth of the estuary. In the Peel-Harvey estuary, samples were obtained using the same techniques but at six weekly intervals during 1980. Specimens held by the Western Australian Museum (WAM) were also examined.

Method of counting and measuring

The methods used for counts and measurements were modified from Munro (1967). The interdorsal scale count is taken from the origin of the last spine of the first dorsal fin to the origin of the first spine of the second dorsal fin along the mid-dorsal line. The number of transverse scales are counted from the origin of the first dorsal fin diagonally downwards and forwards to the upper edge of the mid-lateral band, plus those in the row of scales covering the mid-lateral band, plus the scales counted diagonally upwards and backwards from the origin of the ventral fins to the lower edge of the mid-lateral band. The predorsal scales are counted forwards from the first dorsal fin origin to the head so as to include all the scales in the mid-dorsal line. The position of the origin of the first dorsal

TABLE 1. Body measurements and counts of 30 specimens of *A. wallacei* from the Swan-Avon and Murray Rivers.

Abbreviations: SL, standard length; H max, greatest body depth; H min, least body depth of caudal peduncle; Sn, snout; OD_1, origin of first dorsal fin; OD_2, origin of second dorsal fin; OV, origin of ventral fins; TV, tip of ventral fins; OA, origin of anal fin; TA, last ray of anal fin; T Pec, tip of pectoral fins. Spines and unbranched rays are excluded in the counts for the elements of the second dorsal, anal and pectoral fins. Position of the fins and the anal aperture are expressed as the number of scales in front of (F) or behind (B) the point of reference where zero represents the point of reference.

Measurements and counts	Holotype	Mean, 1 standard deviation and range for holotype and 29 paratypes		
Standard length (SL) in mm	41.2	43.5	5.70	(30.7-54.1)
In SL				
Head	4.1	4.1	0.17	(3.7- 4.4)
H max	6.4	6.6	0.30	(5.9- 7.3)
H min	15.8	15.4	0.78	(13.5-16.9)
Sn-OD_1	2.1	2.1	0.05	(2.0- 2.2)
Sn-OD_2	1.5	1.4	0.04	(1.4- 1.5)
Sn-OV	2.5	2.4	0.09	(2.2- 2.5)
Sn-TV	1.8	1.8	0.05	(1.7- 1.9)
Sn-OA	1.5	1.5	0.04	(1.4- 1.5)
Sn-TA	1.2	1.2	0.05	(1.2- 1.3)
In head				
Eye	3.0	2.9	0.13	(2.7- 3.1)
Interorbital	3.9	3.9	0.19	(3.4- 4.3)
Postorbital	2.4	2.4	0.15	(2.1- 2.7)
In eye				
Snout	1.5	1.5	0.15	(1.2- 1.8)
Premaxilla	1.0	1.0	0.09	(0.8- 1.2)
Premaxillary process	1.8	2.0	0.24	(1.4- 2.4)
Scale counts				
Midlateral scales	39	39.0	0.83	(38-41)
Transverse scales	5.5	5.3	0.37	(5-6)
Predorsal scales	15	14.7	0.58	(14-16)
Interdorsal scales	7	8.2	0.59	(7-9)
Fin element counts				
First dorsal	6	6.5	0.57	(5-7)
Second dorsal	9	8.1	0.55	(7-9)
Anal	10	9.8	0.67	(8-11)
Pectoral	11	10.7	0.48	(10-11)
Position of fins				
OD_1 to TV	F 4	F 3.4	0.69	(1.5- 4.5)
OD_1 to T Pec	B 2.5	B 3.4	0.74	(2.0- 5.0)
OV to T Pec	0	0	0.75	(B 1- F 2)
Other values				
Gill rakers in 1st lower gill arch	15	15.7	0.79	(14-17)
Position of anus to TV	F 1.5	F 1.5	0.56	(0.5- 3.0)

fin is recorded as a number of scales behind the vertical through tips of pectorals and in front of tips of ventrals. The position of the origin of ventrals is recorded as the number of scales behind or in front of the vertical through pectoral tips. The mid-lateral scale count is always taken as the number of scales from the dorsal origin of the pectoral fin to the hypural joint. All measurements were made with calipers and were read to the nearest 0.1 mm.

Morphometric measurements and meristic counts have been recorded for thirty specimens (holotype and paratypes) (Table 1). The general description is based on characters of the holotype, 29 paratypes, and to some extent an additional 77 specimens.

DESCRIPTION

Atherinosoma wallacei, n.sp.

Holotype, WAM — P. 27275-001, 41.2 mm SL, collected by beach seine 21 May 1980, type locality: Guildford, Swan-Avon River system, Western Australia, 31°54'S 115°59'E.

Paratypes — 29 specimens. WAM — P. 27276-001, (4 specimens), 44.8-47.3 mm SL, 21 May 1980, Guildford. WAM — P. 27277-001, (3), 41.8-54.1 mm SL, 6 November 1980, mouth of Murray River, 32°35'S 115°57'E. WAM — P. 27278-001, (2) 43.2 and 44.0 mm SL, 31 October 1980, Shelley Basin, Canning River, 32°00'S 115°53'E.

AMS — I. 22527-001, (5), 37.5-45.2 mm SL, 21 May 1980, Guildford.

BMNH, 1981.11.30.20.22 (3), 47.7-53.5 mm SL, 18 December 1980, Canning River, 32°02'S 115°53'E.

MNHN, 1981-1259 (3), 40.2-43.2 mm SL, 17 October 1979, Guildford.

USNM — 228884, (3), 39.3-43.6 mm SL, 17 October 1979, Guildford.

UMMZ — 209402, (1), 30.7 mm SL, 17 October 1979, Guildford.

UMMZ — 209404, (1), 37.4 mm SL, mouth of Murray River, Western Australia.

UMMZ — 209403, (1), 43.9 mm SL, Shelley Basin, Canning River.

CAS — 48752, (3), 34.5-40.2 mm SL, 17 October 1979, Guildford.

Museum abbreviations, WAM = Western Australian Museum, AMS = Australian Museum Sydney, BMNH = British Museum of Natural History, MNHN = Muséum National D'Histoire Naturelle, USNM = United States National Museum, UMMZ = University of Michigan Museum of Zoology, CAS = California Academy of Sciences.

MORPHOMETRICS (range and mean values)

Head in SL 3.6-4.8 (4.2); greatest body depth in SL 5.5-7.9 (6.6); interorbital in head 3.4-4.3 (3.9); snout in eye 0.9-3.0 (1.6); premaxilla in eye 0.8-1.4 (1.1); height of premaxillary process in eye 1.4-2.4 (2.0); least depth of caudal peduncle in SL 10.4-17.0 (15.2); distance from origin of snout to origin of ventrals 2.2-2.7 (2.4) in SL.

MERISTICS (range and mean values)

Midlateral scales 36-45 (39.4); transverse scales 5-6 (5.3); predorsal scales 12-17 (14.5); interdorsal scales 7-11 (8.6); dorsal fins V-VIII, I,i,7-9; anal I,i,8-11; pectoral I,i,9-13. Gill rakers in first lower gill arch 14-17 (15.7). Vertebrae 38-41 (39.5).

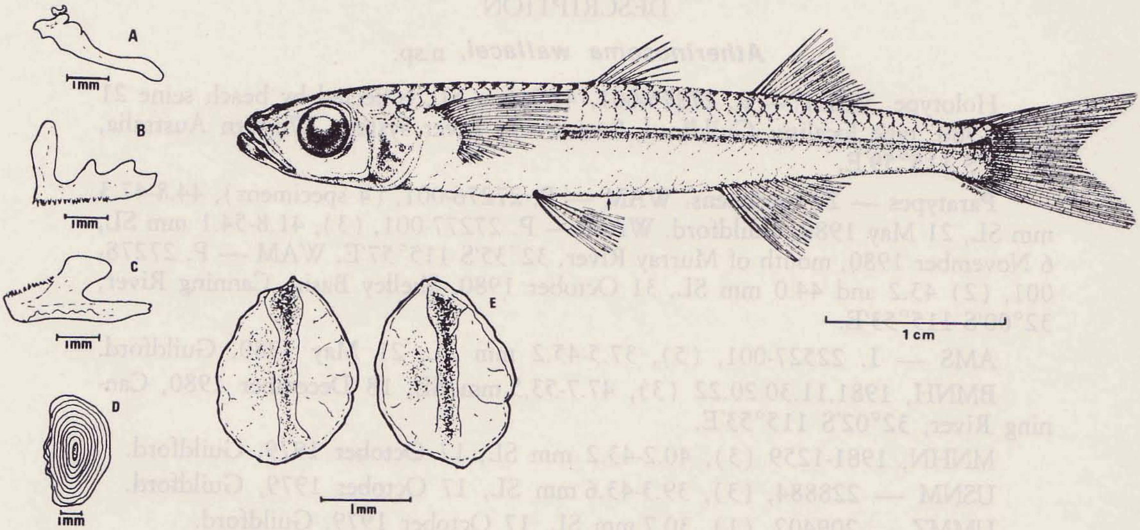

Fig. 1. Holotype of *Atherinosoma wallacei*. (a) Premaxilla, (b) maxilla, (c) dentary and (d) lateral body scales are drawn from an alizarin preparation of an unregistered specimen at different magnifications as indicated. Otoliths (e), medial view with anterior end pointing upwards in diagram.

Origin of first dorsal 1.5-4.5 scales in front of vertical through tips of ventrals and 2-5 scales behind vertical through tips of pectorals. Origin of ventrals from 2 scales in front to 1 scale behind vertical through tips of pectorals. The characters in this paragraph are based only on the holotype and paratypes.

Small slender, subcylindrical species. Mouth moderately small, with posterior end of maxilla reaching a point approximately below anterior margin of orbit. Upper jaw protrusible, but not to the same extent as in many other atherinids. Labial ligament not restricting gape of mouth. Lateral process of premaxilla small

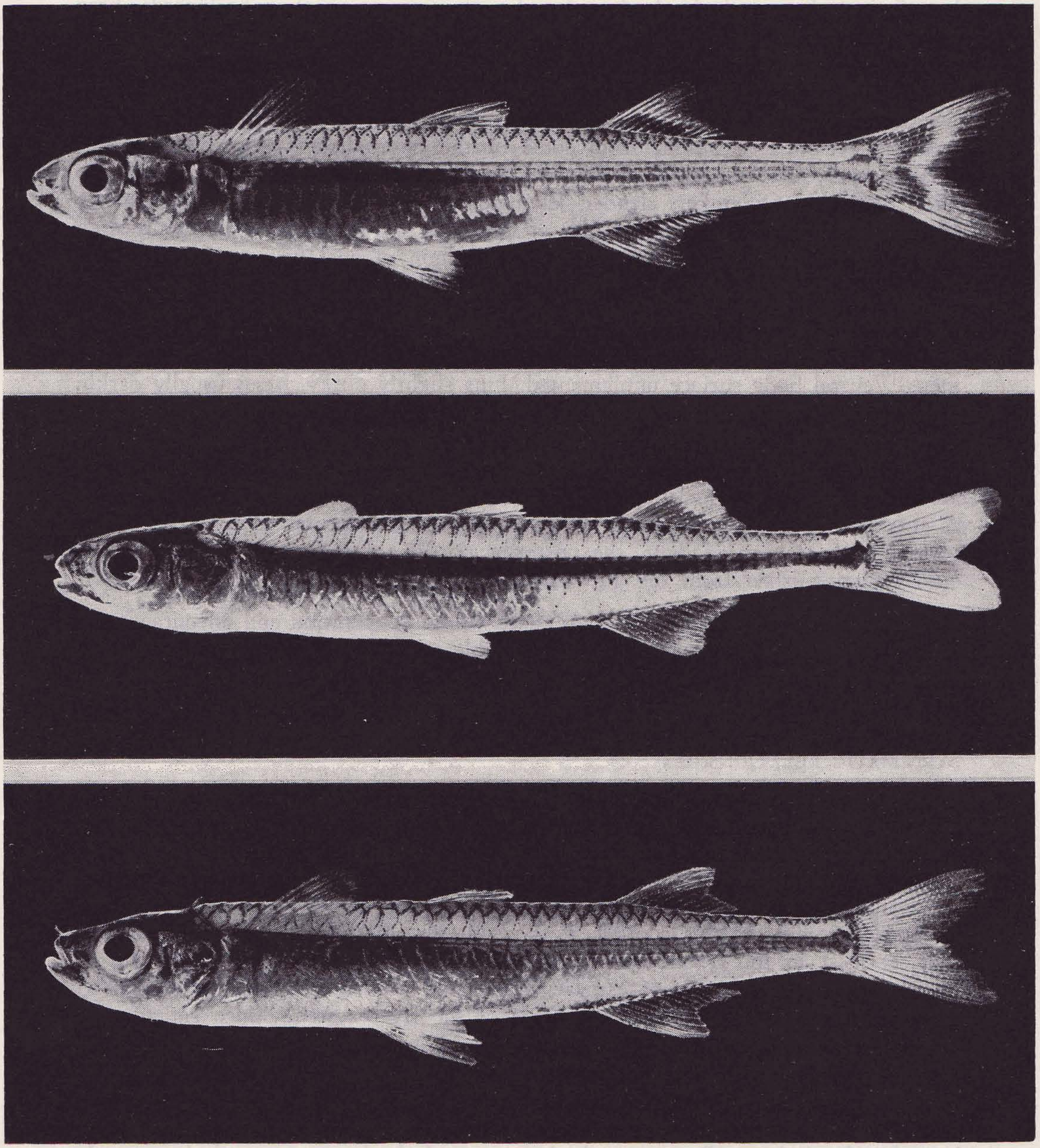

Fig. 2. Photograph of *Atherinosoma presbyteroides* (top), *Atherinosoma elongata* (middle), and *Atherinosoma wallacei* (bottom), with total lengths of 48.9, 48.0 and 46.5 mm respectively.

but distinct, frequently hook shaped and with its apex pointing backwards. Free edge of premaxilla convex and lying obliquely to horizontal. Posterior rami of dentaries very highly elevated. Small teeth are present in upper and lower jaws. Teeth usually present on vomer and palatines and in some specimens on the tongue where they form round irregular patches. In smaller specimens, the teeth may be weakly developed or absent from some of the bones listed above. Body scales small, usually dorsoventrally oval, with circuli complete and distinct. Preopercle with 3-4 scales. Gill rakers slender, length equal to or slightly less than diameter of pupil. Anus always in front of tips of ventral fins. Swimbladder curves upwards and backwards and ends immediately above origin of anal fin.

Preserved specimens whitish, but dark or pigmented in certain regions. Thus, scales above mid-lateral band are outlined by melanophores and the mid-lateral band is black or copper coloured, particularly in recently preserved specimens. Ventral body surface unpigmented. Fins slightly dusky, bases usually darkly pigmented. Dorsum of head, snout and sides of dentary and maxilla dark. Operculum usually silvery or white but with dark dorsal pigmentation. Eye silvery or black. Back of live specimens olive green and bearing scales whose perimeters are etched with dark melanophores. A slight silvery sheen covers the abdomen. A sharply defined lateral bronze stripe runs from operculum to hypural. When viewed with transmited light, the posterior portion of the swim bladder can be clearly distinguished from the gut mass as a translucent structure.

This species is named after J. Wallace whose cooperation and encouragement during this study of atherinids was invaluable.

DISCUSSION

SYSTEMATIC RELATIONSHIPS

Comparisons between the data given in Table 2 for the characters of *A. wallacei* and those obtained for other *Atherinosoma* species in south-western Australia, suggest that *A. wallacei* is more closely related to *A. presbyteroides* than to *A. elongata.* Since the hardyheads are essentially a marine group, it can be postulated that *A. wallacei* evolved from a stock similar to that representing *A. presbyteroides.* In this context, it is of interest that our current study shows that, at least in the Swan-Avon system, the population of *A. presbyteroides* is found primarily in the lower estuary whereas *A. wallacei* is largely confined to the upper estuary and more inland areas of the river system. Since *A. elongata* largely occupies the middle estuary, the atherinid species tend to form a succession up the estuary from *A. presbyteroides* to *A. elongata* to *A. wallacei.* Fish collected in the Murray River, Peel Inlet and Harvey Estuary, together with an examination of WAM material, supports the view that *A. wallacei* tends to be more abundant in reduced salinities (Potter *et al.,* in prep.). Indeed, a survey of the records of atherinids in a number of south-western rivers shows that *A. wallacei* is the only *Atherinosoma* species consistently found in more inland areas of these systems

TABLE 2. Data on characters important in helping to separate the three species of *Atherinosoma* found in the Swan-Avon and Murray Rivers in south-western Australia.

	A. wallacei	*A. presbyteroides*	*A. elongata*
Midlateral scales			
$\bar{x}$	39.5	42.7	38.3
S.D.	1.6	1.1	1.4
Range	36-45	41-45	35-41
n	82	51	38
Gill rakers in lower gill arch			
$\bar{x}$	15.6	17.0	13.2
S.D.	1.4	0.8	0.7
Range	14-17	16-19	12-15
n	107	51	38
Largest gill raker in pupil			
$\bar{x}$	1.2	0.9	1.9
S.D.	0.1	0.1	0.3
Range	0.6-1.5	0.6-1.1	1.4-2.7
n	100	40	42
Rear end of upper jaw.	Extends to approximately the anterior margin of the eye.	Extends below anterior margin of the eye.	Never extends to anterior margin of the eye.
Appearance of swim bladder in fresh specimens viewed by transmitted light.	Posterior portion translucent and clearly distinct from gut mass. Rear end passes upwards and backwards.	Posterior portion opaque and not clearly distinct from gut mass. Rear end passes upwards and backwards.	Posterior portion opaque and not clearly distinct from gut mass. Rear end passes vertically upwards.

(Prince, *et al.,* in press). Moreover, it is evident that the succession formed through the Swan-Avon by the three *Atherinosoma* species is repeated in several different rivers. The significance of the marked tendency for atherinids to segregate in estuaries is discussed in detail in Prince, *et al.* (in press).

Two *Atherinosoma* species (and also very occasionally all three species) have been collected in the same sample. Under these circumstances, it was possible to separate the animals when live, freshly killed or frozen using a combination of the last two characters listed in Table 2. Thus, the presence of a short mouth and a swim bladder terminating in a right angle can be used to distinguish *A. elongata* from *A. presbyteroides* which has a much longer mouth and an upwards slanting end to the swim bladder. While the size of the mouth in *A. wallacei* tends to be intermediate between that of *A. elongata* and *A. presbyteroides,* this species is most clearly distinguished by the fact that the posterior portion of the swim bladder is translucent.

In considering the capture and subsequent identification of individuals, it is of value to record two additional observations pertaining to *A. presbyteroides* and *A. wallacei. A. presbyteroides* tends to be much more fragile and, unless treated with great care, it dies during capture or subsequent transportation to the laboratory. By contrast, *A. wallacei* (and also *A. elongata*) are so much more hardy that they can be used as experimental laboratory animals (McLaughlin, pers. comm.). Furthermore, even when *A. wallacei* and *A. presbyteroides* that had died during capture were brought back on ice, the flesh of the former species remained firm, whereas that of the latter species deteriorated rapidly and became soft. Since these differences are found in animals caught together, they reflect genuine interspecific physiological differences rather than environmentally induced differences.

While living, freshly killed or frozen individuals of the three *Atherinosoma* species can be relatively easily distinguished, identification is more difficult with formalin or alcohol-preserved specimens. However, it is usually possible to distinguish *A. elongata* using just the position of the rear end of the mouth relative to the eye and the relative size of the largest gill raker (Table 2). Although there are significant differences between *A. wallacei* and *A. presbyteroides* in the numbers of mid-lateral scales ($P<0.01$) and gill rakers in the lower gill arch ($P<0.01$), and also the relative size of the longest gill raker ($P<0.01$), the ranges for each of these characters in these two species overlap. However, by considering each of these characters and the relative position of the rear end of the mouth, it is usually possible to distinguish the two species with certainty.

SOME FURTHER NOMENCLATURAL POINTS

The characteristic features of *A. presbyteroides, A. elongata* and *A. wallacei* given in this paper help to justify the use by Ivantsoff (1978) of certain species names for *Atherinosoma* spp. (see earlier section), and to clarify further the reasons for previous taxonomic problems.

Atherinids named *Atherinichthys edelensis* and *Atherinichthys obscurus* were described from the Swan by Castelnau in 1873 and 1876 respectively. Although the types of both of these atherinids are in poor condition, both Whitley (1943) and Ivantsoff (1978) concluded that the two species were synonyms. Castelnau (1873) recorded that in *A. edelensis* the "silvery" colour of the mid-lateral band is retained after preservation. Whitley (1943) stated that these type specimens came from Fremantle. Since the former feature is a characteristic of *A. presbyteroides,* and Fremantle is located in the lower estuary where *A. presbyteroides* is by far the most abundant *Atherinosoma* species, this provides further evidence that *edelensis* is likely to be a synonym of *presbyteroides.* Moreover, the counts for the mid-lateral scales and gill rakers, and also the description of the position of the eye recorded for the type of *edelensis* by Ivantsoff (1978), agree with those given in this paper for *A. presbyteroides* collected mainly from the lower Swan-Avon (Table 1). It should be noted, however, that the atherinid shown in Fig. 2 of Whitley (1955) and designated as *Atherinosoma edelensis* from an inland region (Northam) of the Swan-Avon is *Atherinosoma wallacei* and not *A. presbyteroides.* The point to remember here is that these two species are morphologically very similar and that it was not until the description of *A. wallacei* in the present paper that it was recognised that *A. presbyteroides* was found only in the lower part of the Swan-Avon.

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REFERENCES

CASTELNAU, F. L. (1872). Contributions to the Ichthyology of Australia. No. 1. The Melbourne Fish Market. *Proc. Zool. Acclim. Soc. Vict.* **1:** 29-242.

CASTELNAU, F. L. (1873). Contributions to the Ichthyology of Australia. No. 8. Fishes of Western Australia. *Proc. Zool. Acclim. Soc. Vict.* **2:** 134-5.

CASTELNAU, F. L. (1876). Research on the fishes of Australia. Philad. Cent. Exhib. 1876 (Melbourne, 1875): Official Record. *Intercolonial Exhibition Essays No.* **2:** 1-52.

CHALMER, P. N., HODGKIN, E. P. and KENDRICK, G. W. (1976). Benthic faunal changes in a seasonal estuary of south-western Australia. *Rec. West. Aust. Mus.* **4:** 338-410.

CHUBB, C. F., HUTCHINS, J. B., LENANTON, R. C. J. and POTTER, I.C. (1979). An annotated checklist of the fishes of the Swan-Avon river system, Western Australia. *Rec. West. Aust. Mus.* **8:** 1-55.

CHUBB, C. F., POTTER, I. C., GRANT, C. J., LENANTON, R. C. J. and WALLACE, J. (1981). The age structure, growth rates and movements of sea mullet. *Mugil cephalus* L., and yellow-eye mullet, *Aldrichetta forsteri* (Valenciennes), in the Swan-Avon river system. *Aust. J. mar. Freshwat. Res.* **32:** 605-28.

GÜNTHER, A. (1861). *Catalogue of the acanthopterygian fishes in the British Museum.* **3:** 1-586, London.

IVANTSOFF, V. (1978). Taxonomic and systematic review of the Australian fish species of the family Atherinidae with references to related species of the Old World. Ph.D. Thesis, Macquarie University, North Ryde, N.S.W.

JOHNSTON, R. M. (1883). General and critical observations on the fishes of Tasmania; with a catalogue of all the known species. *Pap. Proc. Roy. Soc. Tas.* **1882:** 53-144

JUTSON, J. T. (1934). The physiography of Western Australia. *Bull. geol. surv. West. Aust. No.* **95** (2nd ed.): 1-358.

KLUNZINGER, C. B. (1879). Die v. Muller'sche Sammlung australischer Fische in Stuttgart. *Sitzungsb. K. Akad. Wiss. Wien.* **80:** 325-40.

McCULLOCH, A. R. (1911). Report on the fishes obtained by F.I.S. "Endeavour" on the coasts of New South Wales, Victoria, South Australia and Tasmania. Part 1. *Zool. Res. Endeavour* **1**(1): 1-87.

MUNRO, I. S. R. (1958). Family Atherinidae. *In* Handbook of Australian Fishes, No. 24: 97-100, No. 25: 101-104. *Suppl. Aust. Fish. Newsl.* **17**(6): 17-20 and **17**(7): 17-20.

MUNRO, I. S. R. (1967). The fishes of New Guinea. (Department of Agriculture, Stock and Fisheries: Port Moresby). 650pp.

OGILBY, J. D. (1895). On two new genera and species of fishes from Australia. *Proc. Linn. Soc. N.S.W. (2),* **10**(2): 320-4.

PRINCE, J. D., POTTER, I. C., LENANTON, R. C. J. and LONERAGAN, N. R. (in press). Segregation and feeding of atherinid species (Teleostei) in south-western Australian estuaries. *Aust. J. mar. Freshwat. Res.*

RICHARDSON, J. (1843). Contributions to the Ichthyology of Australia. *Ann. Mag. Nat. Hist.* **11:** 169-82.

SCHULTZ, L. P. (1948). A revision of six subfamilies of atherine fishes, with descriptions of new genera and species. *Proc. U.S. Nat. Mus.* **98:** 1-48.

WHITLEY, G. P. (1943). Ichthyological description and notes. *Proc. Linn. Soc. N.S.W.* **68**(3,4): 114-44.

WHITLEY, G. P. (1955). Freshwater atherines from Western Australia. *W. Aust. Nat.* **5**(3): 25-31.

WHITLEY, G. P. (1958). The freshwater fishes of Australia. 12. Hardyheads. *Australasian Aqualife,* **2**(9): 12-8.